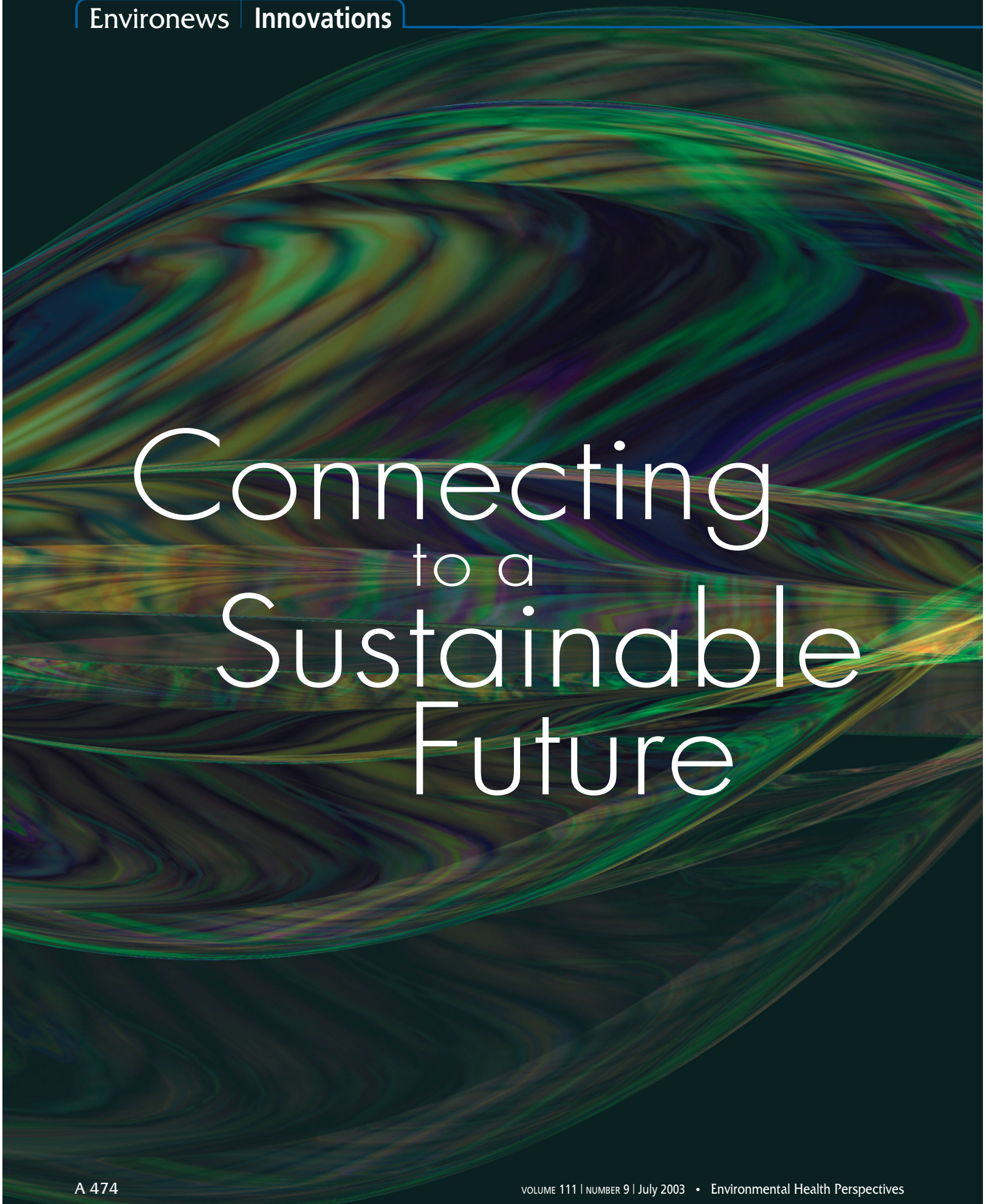
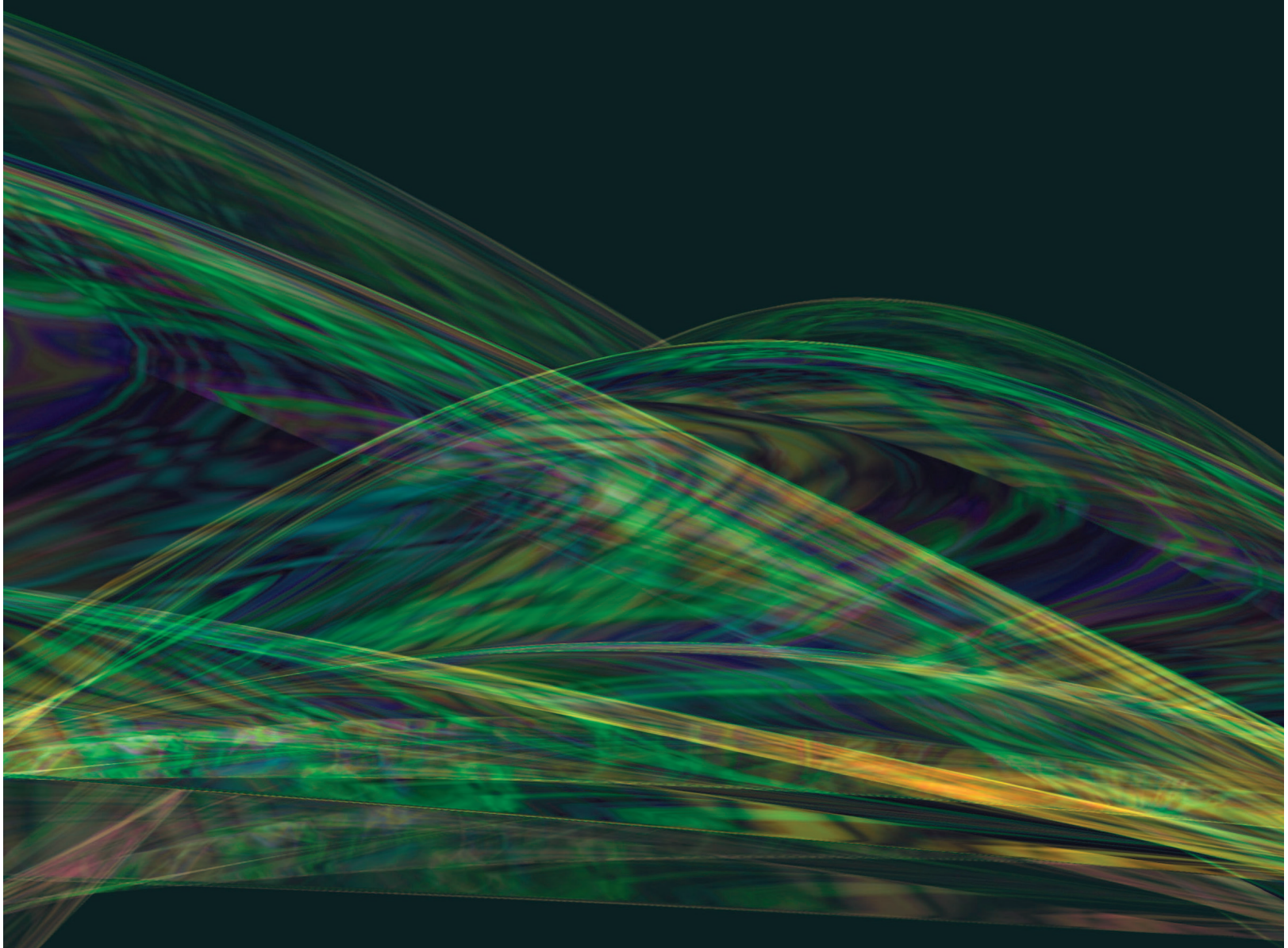


Connecting to a Sustainable Future



Brand X Images

Planet Earth has a problem, a big problem. The planet's finite resources are overburdened by the unceasing demands of overconsumption. Fortunately, there is an antidote to the problem: sustainable development, a concept that has taken root and is gaining acceptance at all levels, from the international political structure to the corporate world to the grassroots. Thanks to a variety of technological advances affecting everything from power consumption to product identification, information and communications technologies (ICT) could very well play a pivotal role in the ultimate attainment of a sustainable planet.

The core goal of sustainable development is to shift the world's economic mindset from the "take-make-waste" philosophy to the so-called triple bottom line—a new paradigm in which value is derived from economic, societal, and environmental benefits working in synergy to achieve balanced growth and prosperity within a renewable framework. ICT contributes to this shift by enabling alternatives to current ways of doing business that allow win–win–win scenarios characterized by healthy economic returns in harmony with concomitant societal and environmental benefits. Whether it's automating our infrastructural networks or streamlining communications, digitizing electricity or selling functionality, telecommuting or reducing inventories, ICT is the basis for a stunning breadth of new technologies that could lead to more sustainable commerce.

Products Become Services

As the trend that some call the Information Economy takes hold, more and more products are evolving into services, with companies selling functionality and information instead of physical goods. This growing trend can bring with it considerable benefits to the environment. "Moving bits, not atoms" (as Nicholas Negroponte put it in his seminal 1995 work, *Being Digital*) avoids much of the environmental impact associated with the production, packaging, distribution, and disposal of objects. And products that are essentially information are rapidly moving into the digital world—a phenomenon known as "dematerialization."

Many forms of information are being dematerialized, collectively helping to at least slow the ongoing increase in the consumption of paper—an increase from 84.9 million tons in 1990 to 97.3 million tons in 2002. Catalogs, promotional materials, manuals, telephone books, bills, checks, taxes, tickets, photographs, and letters are all rapidly entering the digital realm, saving not only paper and related materials but also storage space, transportation costs, and waste, while adding significantly to business efficiency and productivity.

In the 1999 report *The Internet Economy and Global Warming: A Scenario of the Impact of E-commerce on Energy and the Environment*, the Annandale, Virginia–based nonprofit Center for Energy & Climate Solutions (CECS) predicted that the Internet could save 2.7 million tons of paper every year by 2003, equaling a reduction of 10 million tons of carbon dioxide emissions, and that both figures could double by 2008. *Sustainability at the Speed of Light: Opportunities and Challenges for Tomorrow's Society*, a 2002 report by WWF Sweden on the role of ICT in sustainable development, cites many other examples of savings: Cisco saved an estimated $50 million per year storing its product and pricing information on the Internet. AT&T cut annual paper consumption by more than 400 tons by changing from a 1,500-page paper personnel manual to an online resource. Ericsson is realizing enormous cost and paperwork savings by instituting an automated procurement system. PriceWaterhouseCoopers predicts that by 2004, more than 13% of all consumer bills in the United States will be presented and paid electronically. And the Universal Postal Union predicts that e-mail will replace 12% of business-to-business mail and 5% of business-to-consumer mail in Western Europe and North America by 2005. Besides the paper saved, the transportation needed to send these pieces of paper through the mail also might be expected to decrease.

Other transportation savings are being realized in traffic-saturated cities such as Tokyo, Paris, and San Francisco, where urban dwellers are now able to exchange the expense, inefficiency, and environmental impact of automobile ownership for the service of as-needed access to a car, thanks to an Internet-enabled concept called "car-sharing." The San Francisco nonprofit City CarShare seeks to reduce private car ownership and usage in the city by allowing residents to reserve a shared car through an Internet system that locates available cars and issues drivers electronic keys. Thanks to a recent grant, City CarShare now even offers access to 10 eco-friendly electric vehicles for short nonhighway trips. The organization hopes that its car-sharing and electric vehicle program will contribute to a reduction in air pollution in the San Francisco area.

Even the appliances in the digital household may soon become more environmentally efficient by being "servicized." Merloni Elettrodomestici, a large Italian appliance manufacturer, and Sweden-based Electrolux, the world's largest appliance manufacturer, are testing the concept of pay-per-use laundry using state-of-the-art washers with sensors that optimize the length of the wash cycle and the amount of water used. Consumers pay only for the service of doing their laundry; they do so in their home but without owning the equipment. The company monitors energy use, maintains the machines, and recycles or refurbishes them when they are no longer operating at optimum efficiency: after 4–5 years. Families save money, and the overall environmental impact of clothes washing—90% of which comes from actual washer use, according to *Sustainability at the Speed of Light*—is substantially reduced.

Un-building and Un-traveling

According to *The Internet Economy and Global Warming*, by 2007 the combined effects of business-to-business and business-to-consumer e-commerce in the United States could obviate the need for 1.5 billion square feet of retail space, 1 billion square feet of warehouse space, and as much as 2 billion square feet of commercial office space—the equivalent of almost 450 Sears Towers. The environmental benefits of this "un-building" could be dramatic. The CECS estimates that each year energy savings and avoided construction would save the equivalent of 31 average power plants' outputs and 67 billion cubic feet of natural gas, and would prevent the release of 75 million metric tons of greenhouse gases.

"Telework," people working from home or in virtual offices, is one of the ICT-related activities contributing to unbuilding, with the added environmental benefit of reductions in commuting. According to Joseph Romm, CECS executive director and former acting assistant secretary of energy efficiency and renewable energy at the U.S. Department of Energy, "the single biggest piece of underutilized infrastructure in the U.S. economy is American homes when people aren't in them." He adds, "Clearly, if people can work out of their homes, and that displaces the need to build an office building, that's a very significant saving in energy and resources." Large organizations are increasingly recognizing that telework can no longer be considered just an employee perk or an alternative work arrangement, but rather can be a productive and profitable element of their business model.

However, some recent studies have shown that many people find the workplace less stressful than the home when it comes to actually working, and harbor concerns about the possible negative impact on their careers when they rarely see their superiors and coworkers in person. There is also some disagreement among experts about the extent of the environmental savings from telework. Although automobile commuting and the demand for office space are lower, increases in personal travel and home office use may diminish the overall environmental benefits generated by telework.

Telework also contributes to "un-traveling"—the use of ICT to replace business travel. In this instance, however, the promise of ICT to contribute to sustainability is as yet largely unrealized. Although the technology to conduct remote meetings exists, and has for some time, it is still relatively immature and thus unlikely to have a major impact in the near term, according to *Sustainability at the Speed of Light*. The use of videoconferencing, audioconferencing, webconferencing, and computer collaboration to replace business travel is growing, but barriers to its widespread proliferation remain. Many people still prefer to meet face-to-face, are uncomfortable or dissatisfied with the technology, and do not yet perceive its use as part of a corporate culture supporting sustainability. The technology is improving, however, and travel costs are rising, so it appears probable that

the use of virtual meetings will gradually increase, as will the environmental dividends they promise.

The Meta-Network

The Internet is in the process of becoming part of a pervasive computational fabric, a worldwide "meta-network" of devices capable of doing a great deal of energy-saving work autonomously through millions of connections to miniscule pumps, actuators, and sensors. It has been predicted that within just 10 years more *things* than *people* will be using the Internet. Michael Mayer, head of IBM Pervasive Computing, is quoted in the 22 April 2001 issue of *The New York Times Magazine* as asserting that this "smart future" will include more and more machines talking to machines—our refrigerators, our cars, our tools, our clothes, and other items performing microelements of tasks without human intervention.

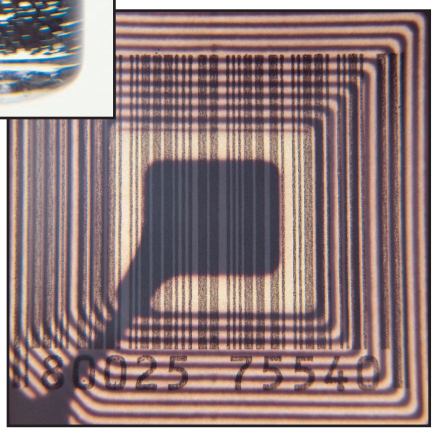
Even today, only 2% of the 8 billion microprocessors produced this year will end up in computers, according to David Rejeski, a resident scholar at the Woodrow Wilson International Center for Scholars in Washington, D.C., and John Seely Brown, former director of Xerox PARC, writing in the 18 December 2000 issue of *The Industry Standard*. The other 98%, they write, "will be embedded in the world around us." They further write that as these countless little units of intelligence "become increasingly interconnected—with each other, the Internet, and the physical world—they will form the technological foundation of the next environmental revolution."

Rejeski says the meta-network will bring substantial environmental benefits: "The largest long-term potential game changer for the environment is the 'convergence of networks' that will happen when we overlay pervasive information networks on other networks such as our energy grids, transportation system, water supply system, et cetera. This will open up new possibilities for the understanding, micromanagement, and optimization of complex networks, with large environmental impacts."

Writing in *Sustainability at the Speed of Light*, Rejeski says that ICT will enable complex data systems of a scope previously impossible. The sheer size of the individual component systems that might comprise such a meta-network—for example, agroecological systems, power distribution systems, oceans, urban traffic, water- and airsheds, and logistics systems—implies inherently large environmental impacts in terms of streamlining research and applying solutions. "Suddenly," he writes, "systems that have been too large and expensive to instrument become tractable targets for scientific inquiry."

Life Cycle Management of Objects

Before the end of this decade, there will be an "Internet of things." The Auto-ID Center, a partnership of almost 100 global companies and 5 of the world's leading research universities, is developing a global infrastructure that will allow computers to identify any object anywhere in the world instantly, through the use of radio-frequency identification tags. Every product, and even individual parts, will have its own unique identity (an "electronic product code," or ePC) burned onto a tiny microchip equipped with an antenna.



Automated environment. Technologies including microchips and identification tags with barcodes may someday automate many processes, thereby saving energy and reducing waste.

A global computer network, layered on top of the Internet, has been developed to coordinate and process the mountains of information this system will generate. For business, radio-frequency identification tags will revolutionize management of the supply chain, eliminating all guesswork from inventory control, allowing precise fulfillment of demand, and facilitating optimized cradle-to-grave tracking of products, including recycling and refurbishment. Observers are optimistic that the system will generate substantial environmental benefits as well. Obviously, massive potential gains in efficiency could eventually translate into massive energy savings.

Rejeski adds, however, that the process of connecting environmental information to the objects in the product tagging system is not a given, and will only come about as a result of proactive work on the part of the policy community with the business sectors implementing the tagging systems. Without the addition of this information, the environmental benefits that can be expected from it will be limited to absolute increases in logistics efficiency.

Digital markers are already in use on a much smaller scale by conservation groups and researchers to gather information about the activities of a wide variety of animals, including endangered species. A passive integrated transponder tag is injected under an animal's skin, allowing its movements to be tracked by antenna systems over a wide area. The data are collected and entered into databases in real time via the Internet, giving biologists a valuable new tool in efforts to understand the animals and preserve their often fragile habitats.

ICT is also even now enabling drastic reductions in inventories, and increases in recycling and reselling of waste materials and products. The Home Depot uses ICT systems to almost completely eliminate the need for warehousing; 85% of its products are shipped directly from manufacturers to stores, resulting in significant savings in energy, transportation, and land use—and enviable profit margins. The Internet has spawned a huge business-to-business marketplace in industrial secondary materials. With the widened audience afforded by the Internet, many companies have found the online reselling of unwanted or surplus components and products to be an important new source of revenue, while the environment has benefited from concomitant reductions in waste disposal and landfill pressure.

Web-Based Micromanagement

The ability to micromanage energy usage through Internet-enabled communication networks has already been rolled out in pilot form. Digital intelligence allowing the remote monitoring and control of devices can maximize efficiency.

For example, the Long Island Power Authority (LIPA), through its LIPA*edge* program, allows both the utility and its

Auto-ID Center

customers to remotely control digital thermostats on central air conditioners via an Internet-based system. This enables LIPA to temporarily adjust the temperature or compressor operation of thousands of units during peak summer demand hours, saving substantial load on the system. LIPA*edge* operators can also remotely program the thermostat for homeowners without Internet access.

The system works through telephone lines; the thermostat itself has a web-linked chip in it that allows it to receive code and be adjusted or preprogrammed. As of March 2003, there had been 22,000 installations. The company estimates that when the program is fully implemented, 30,000 customers will be enrolled, saving up to 30 megawatts of summer peak demand—the equivalent of an additional turbine generator. LIPA also estimates that customers will be able to save 10–15% of their energy costs by fine-tuning their air conditioning use with the programmable thermostats and by being able to adjust them from locations outside the home.

The electricity industry itself recognizes the possibilities of the next wave of digital intelligence. In 1999, the Electric Power Research Institute (EPRI), a nonprofit industry-supported think tank based in Palo Alto, California, published the *Electricity Technology Roadmap*, a call to action that predicts that "the transformation of the traditional power supply network [i.e., the grid] into a truly customer-managed service network. When electrons are integrated with real-time information, customers can build customized services that are tailored to their particular needs."

EPRI dubs these services "intellectrics," and speculates that an eventual full proliferation of such innovations in the United States could halve energy intensity (that is, energy consumed per dollar of gross domestic product, a key indicator of energy trends), greatly reduce waste output (as the waste from one process becomes the feedstock of the next), and, startlingly, add at least a trillion dollars a year to the U.S. gross domestic product thanks to increased productivity and efficiency.

In the near future, perhaps intellectrics can be used to efficiently power "domotics"—the smart appliances in the digital household. Merloni has engineered a line of smart refrigerators, washing machines, ovens, and dishwashers designed to be remotely micromanaged for optimal power efficiency, again by both the user and the utility. These interactive devices call on the power of the ePC to help them work their magic.

For example, with every item of food having its own digital identification tag, including when the item was made and purchased, the fridge will be able to read the tags wirelessly as items are put in or removed. According to a Merloni press release, the interactive display on the appliance "will indicate what food it contains, the optimum preservation temperature, best-before dates, descriptions of food and its nutrition data, as well as recipes that can be prepared using the available food." Other appliances can sense how dirty your dishes are and adjust accordingly, display recipes you've downloaded directly into the oven (which is also capable of cleaning itself automatically), and alert you to remove that white T-shirt you inadvertently threw in with a load of colored clothes.

Wash of the future? Merloni's "smart" clothes washer can be remotely micromanaged for optimum efficiency.

Mass Customization

Mass customization may sound like an oxymoron, but as the Internet continues to proliferate and more companies learn how to take advantage of direct contact with their customers, the concept may become a key organizing principle of business in the years to come. It could also become a key driver of sustainability, through environmental benefits such as production, storage, and transportation energy savings; reduced use of materials by precisely matching demand with production; and reduced waste by obviating the need for elaborate packaging and eliminating production overruns. However, unless customers are provided with the appropriate information about the environmental impact of their buying decisions, such as the additional energy use required to ship their individual order via overnight service, the benefits of mass customization may be compromised.

Right now, Dell will build a computer system to customer specifications, communicated online, allowing the company to trim inventories of components that quickly become obsolete in this ever-changing industry. McGraw-Hill's Primis Custom Publishing offers textbook publishing on demand on the Internet, allowing faculty to customize their textbooks according to their specific needs, choosing from thousands of available chapters and documents. ChemStation International of Dayton, Ohio, has established a national network for customized production and distribution of industrial cleaning chemicals. The company custom-formulates environmentally friendly products according to the needs of individual customers, and through computerized monitoring, delivers just enough of the materials just in time to company-maintained refillable tanks on the customers' premises. The company does all the handling, with its own trained personnel and specially designed dispensers. So, aside from the economies involved, the system enhances employee safety, reduces chemical waste and the possibility of spills, and eradicates drum handling and disposal at the site. It is likely that this type of mass customization will be available in the near future to users of pesticides and other toxic, environmentally sensitive materials.

Guarded Optimism

Whether the marvels of ICT innovation will succeed in ushering in a new era of sustainable development remains to be seen, of course. Certainly, ICT cannot be seen as a panacea for the world's many dramatic imbalances. It seems safe even now, however, to predict that ICT will contribute significantly to efforts to accomplish the goal of sustainability.

Merloni Elettrodomestici

Experts express guarded optimism, along with a healthy dose of skepticism regarding the motivations and dedication of the primary actors in the global marketplace. As *Sustainability at the Speed of Light* editor Dennis Pamlin concludes in that report, "A positive outcome for humanity and for the Earth depends on decisions made today. Before the end of the first decade of this third millennium, we will be able to see whether ICT's applications have come to be dominated by sustainability, or whether they are primarily driven by influential groups for their own short term benefit. . . . We have the tools in front of us, we have the resources, and we understand the challenges and the opportunities. The question is whether a sufficient number of individuals that have the possibility to influence the development of ICT will dare to go beyond their current roles and have the courage to take innovative initiatives."

ICT is, of course, simply a tool. Like any tool, it can be used for good or ill, depending on the motivation of the user. For ICT to become a prime contributor to the accomplishment of sustainable development will require active involvement by people motivated to achieve it. "Very few of the gains described [in *Sustainability at the Speed of Light*] will just happen without some serious and proactive work by the environmental policy community," says Pamlin. "Above all, we need much more research done to assess the potential impacts of ICT on the environment and inform the policy-making process."

Rejeski expresses much the same sentiment: "Whether ICT has positive or negative impacts on the environment is often dependent on a wide range of variables, many of which may be hard to predict *a priori* or address with traditional environmental policy approaches. . . . Public sector policies and targeted business strategies may be very important in securing such public goods as new information technologies emerge."

Ernie Hood

Suggested Reading

Cohen N. 1999. Greening the Internet: ten ways e-commerce could affect the environment and what we can do. iMP: The Magazine on Information Impacts. October. Available: http://www.cisp.org/imp/october_99/10_99cohen.htm [accessed 23 May 2003].

E-commerce, the Internet, and the environment [special issue]. 2003. J Ind Ecol 6(2).

Global e-Sustainability Initiative. 2002. Industry as a Partner for Sustainable Development: Information and Communications Technology. Paris, France:United Nations Environment Programme. Available: http://www.uneptie.org/outreach/wssd/docs/sectors/final/ICT.pdf [accessed 23 May 2003].

Romm J. 1999. The Internet Economy and Global Warming. Annandale, VA: Center for Energy & Climate Solutions. Available: http://www.cool-companies.org/energy/paper1.cfm [accessed 23 May 2003].